US009154273B2

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Moon et al.

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(45) **Date of Patent: Oct. 6, 2015**

(54) **METHOD AND APPARATUS FOR DATA TRANSMISSION USING A DATA FRAME**

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(73) Assignee: **LG ELECTRONICS INC.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 27 days.

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PCT Pub. Date: **Jul. 1, 2010**

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(51) **Int. Cl.**
H04L 5/00 (2006.01)
H04L 5/14 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 5/0007*** (2013.01); ***H04L 5/0064*** (2013.01); ***H04L 5/1469*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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Primary Examiner — Chirag Shah
Assistant Examiner — Joshua Smith
(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

A method and apparatus for transmitting data using a frame in a broadband wireless communication system are disclosed. The method for transmitting and receiving data in a broadband wireless communication system includes: setting a data frame for transmitting and receiving data through uplink and downlink; and transmitting and receiving data through the set data frame, wherein the data frame includes one or more first subframes and one or more second subframes including a different number of data symbols from that of data symbols of the first subframe.

1 Claim, 12 Drawing Sheets

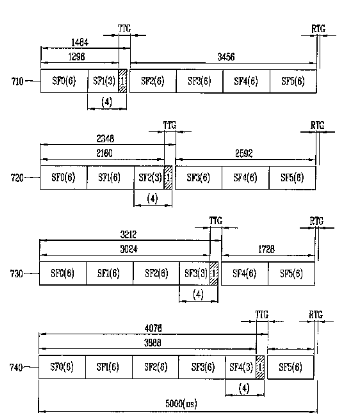

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FIG. 1

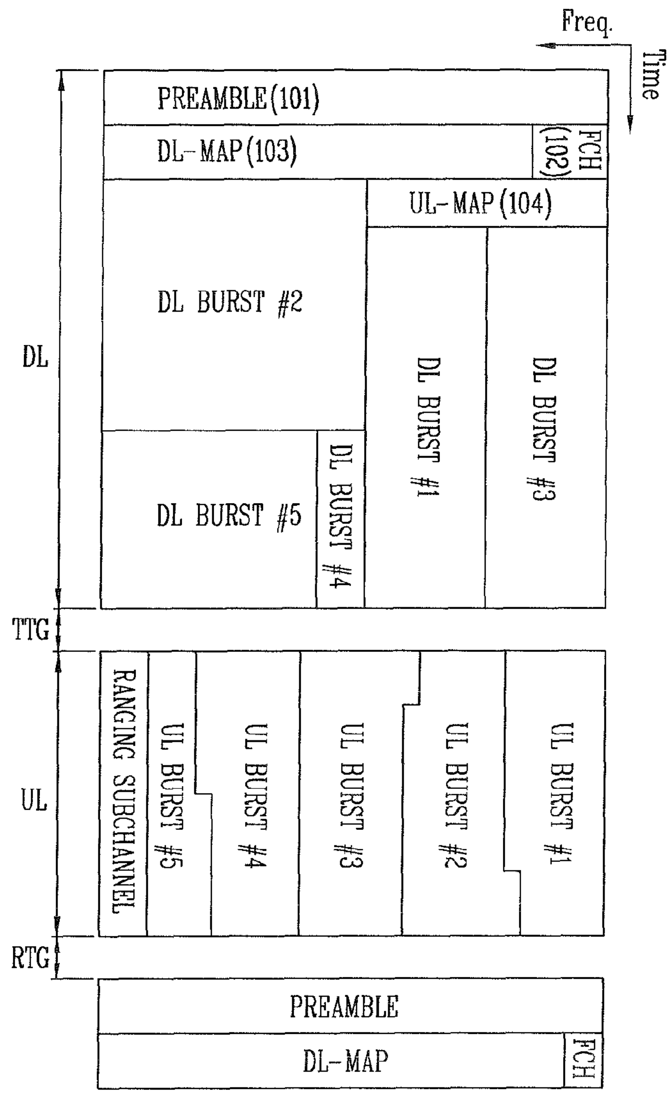

Freq.
Time
PREAMBLE(101)
DL-MAP(103)
FCH (102)
UL-MAP(104)
DL BURST #2
DL BURST #1
DL BURST #3
DL BURST #5
DL BURST #4
DL
TTG
RANGING SUBCHANNEL
UL BURST #5
UL BURST #4
UL BURST #3
UL BURST #2
UL BURST #1
UL
RTG
PREAMBLE
DL-MAP
FCH

FIG. 2

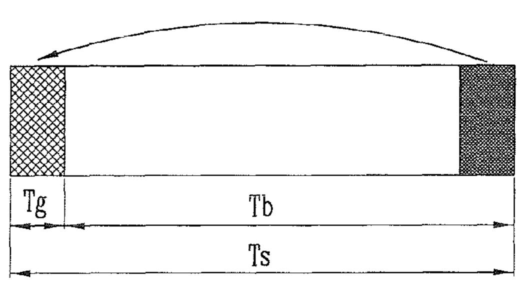

Tg
Tb
Ts

FIG. 3

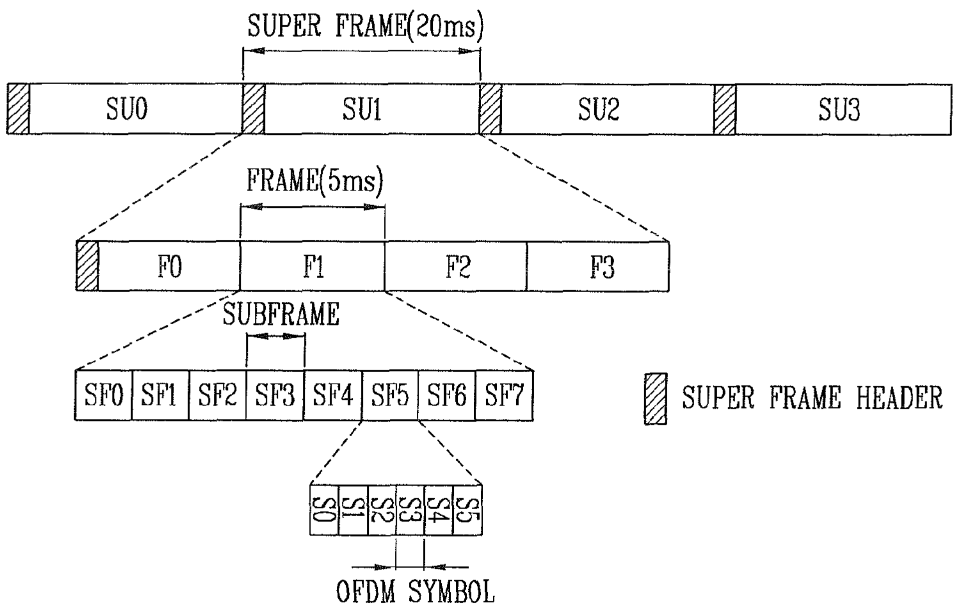

SUPER FRAME(20ms)
SU0
SU1
SU2
SU3
FRAME(5ms)
F0
F1
F2
F3
SUBFRAME
SF0
SF1
SF2
SF3
SF4
SF5
SF6
SF7
SUPER FRAME HEADER
S0
S1
S2
S3
S4
S5
OFDM SYMBOL

FIG. 4

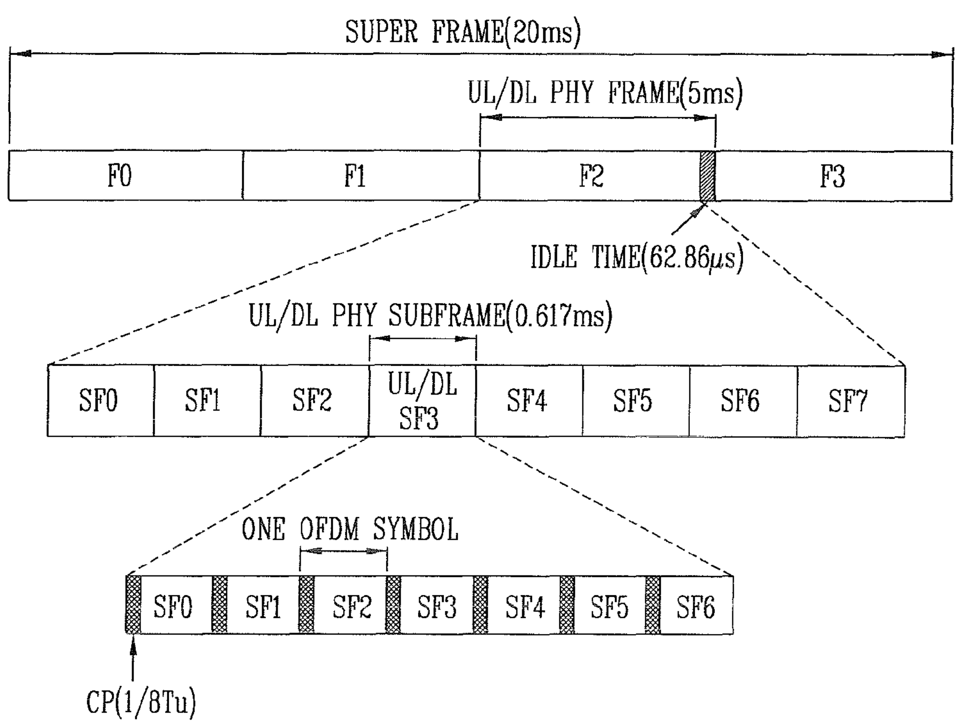

SUPER FRAME(20ms)
UL/DL PHY FRAME(5ms)
F0
F1
F2
F3
IDLE TIME(62.86μs)
UL/DL PHY SUBFRAME(0.617ms)
SF0
SF1
SF2
UL/DL SF3
SF4
SF5
SF6
SF7
ONE OFDM SYMBOL
SF0
SF1
SF2
SF3
SF4
SF5
SF6
CP(1/8Tu)

FIG. 5

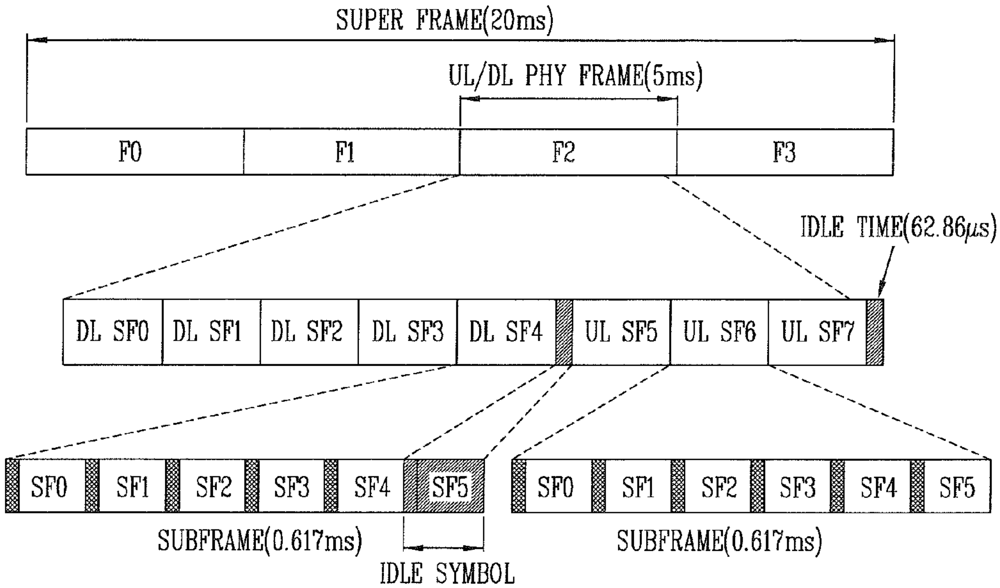

SUPER FRAME(20ms)
UL/DL PHY FRAME(5ms)
F0
F1
F2
F3
IDLE TIME(62.86μs)
DL SF0
DL SF1
DL SF2
DL SF3
DL SF4
UL SF5
UL SF6
UL SF7
SF0
SF1
SF2
SF3
SF4
SF5
SF0
SF1
SF2
SF3
SF4
SF5
SUBFRAME(0.617ms)
IDLE SYMBOL
SUBFRAME(0.617ms)

FIG. 6

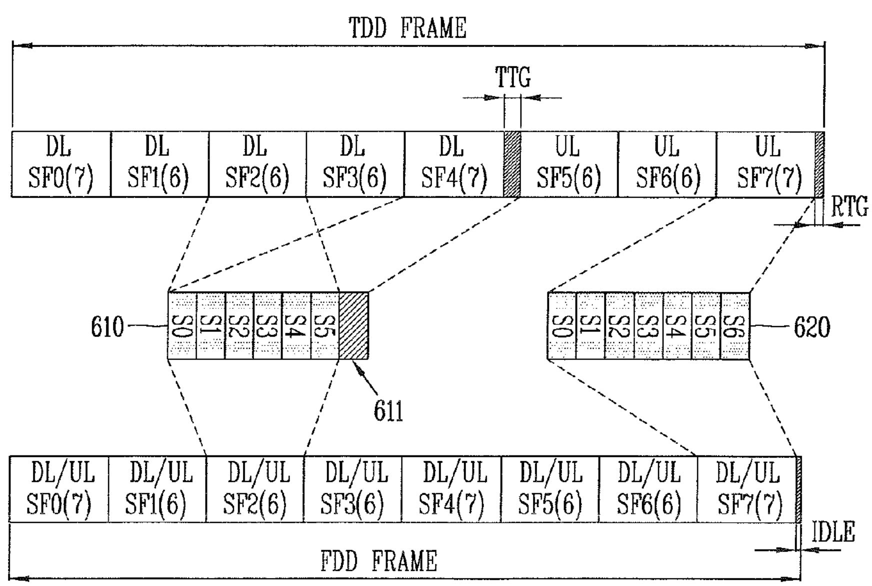

TDD FRAME
TTG
DL SF0(7)
DL SF1(6)
DL SF2(6)
DL SF3(6)
DL SF4(7)
UL SF5(6)
UL SF6(6)
UL SF7(7)
RTG
610
S0
S1
S2
S3
S4
S5
611
S0
S1
S2
S3
S4
S5
S6
620
DL/UL SF0(7)
DL/UL SF1(6)
DL/UL SF2(6)
DL/UL SF3(6)
DL/UL SF4(7)
DL/UL SF5(6)
DL/UL SF6(6)
DL/UL SF7(7)
IDLE
FDD FRAME

FIG. 7

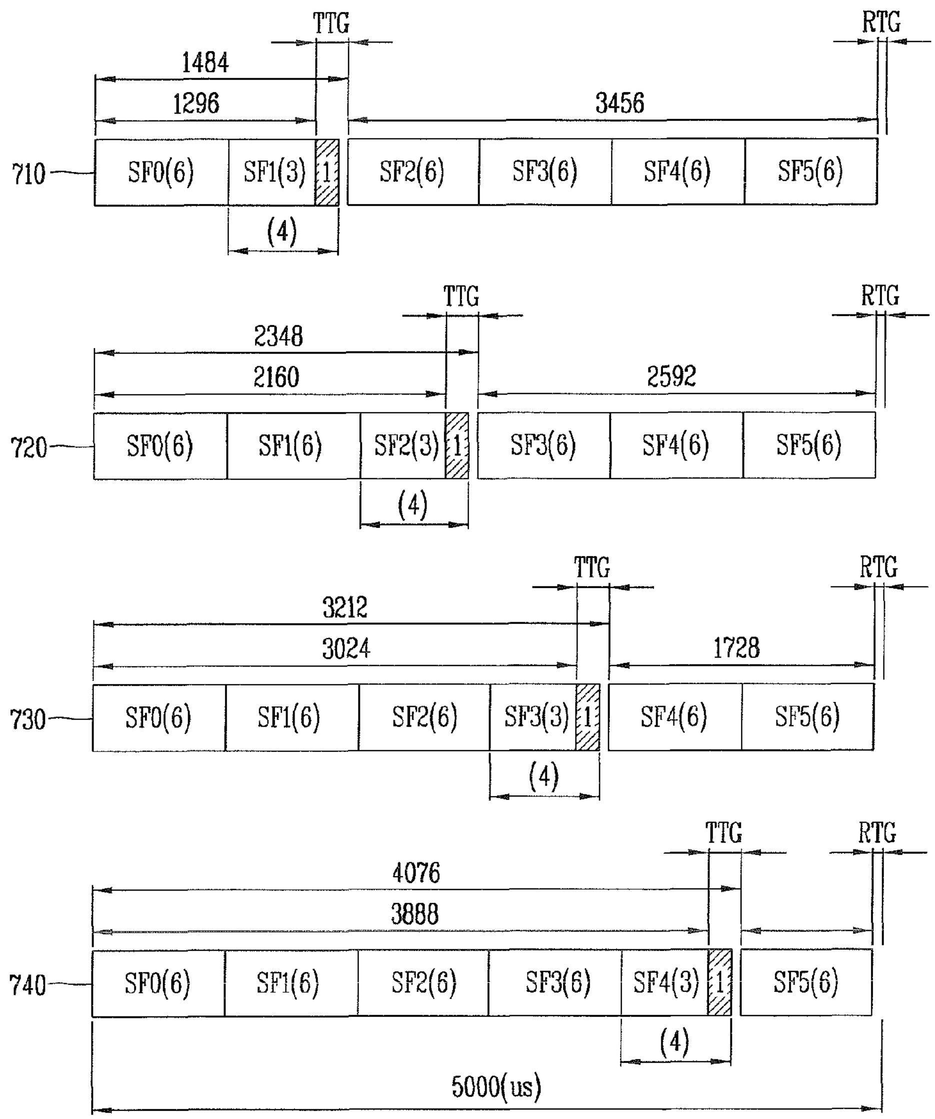
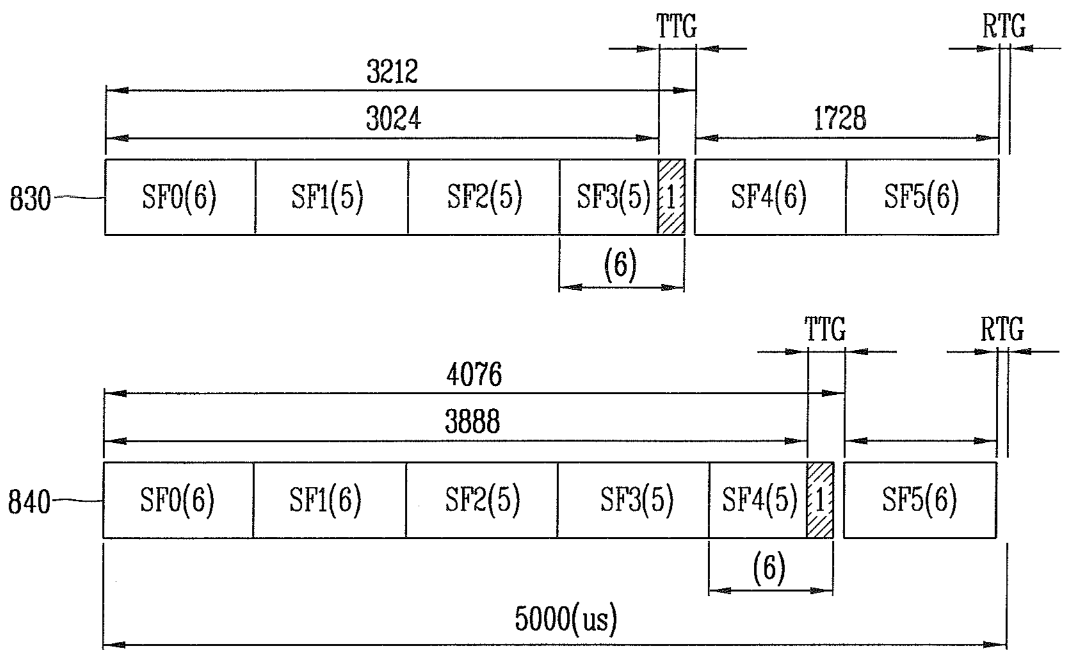

TTG
RTG
1484
1296
3456
710
SF0(6)
SF1(3)
1
SF2(6)
SF3(6)
SF4(6)
SF5(6)
(4)
2348
2160
2592
720
SF0(6)
SF1(6)
SF2(3)
SF3(6)
(4)
3212
3024
1728
730
SF3(3)
(4)
4076
3888
740
SF4(3)
(4)
5000(us)

FIG. 8



TTG
RTG
3212
3024
1728
830
SF0(6)
SF1(5)
SF2(5)
SF3(5)
1
SF4(6)
SF5(6)
(6)
TTG
RTG
4076
3888
840
SF0(6)
SF1(6)
SF2(5)
SF3(5)
SF4(5)
1
SF5(6)
(6)
5000(us)

FIG. 9

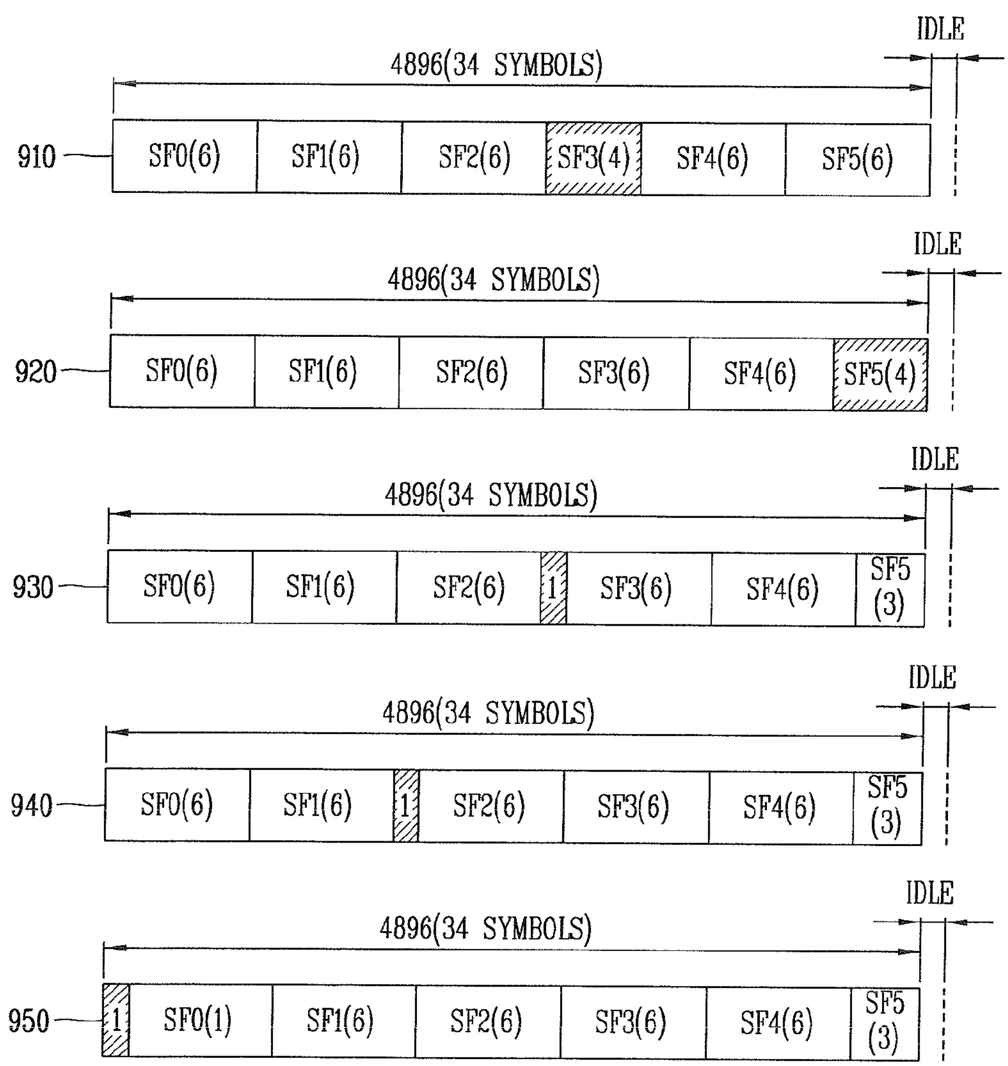

IDLE
4896(34 SYMBOLS)
910
SF0(6)
SF1(6)
SF2(6)
SF3(4)
SF4(6)
SF5(6)
IDLE
4896(34 SYMBOLS)
920
SF0(6)
SF1(6)
SF2(6)
SF3(6)
SF4(6)
SF5(4)
IDLE
4896(34 SYMBOLS)
930
SF0(6)
SF1(6)
SF2(6)
1
SF3(6)
SF4(6)
SF5 (3)
IDLE
4896(34 SYMBOLS)
940
SF0(6)
SF1(6)
1
SF2(6)
SF3(6)
SF4(6)
SF5 (3)
IDLE
4896(34 SYMBOLS)
950
1
SF0(1)
SF1(6)
SF2(6)
SF3(6)
SF4(6)
SF5 (3)

FIG. 10

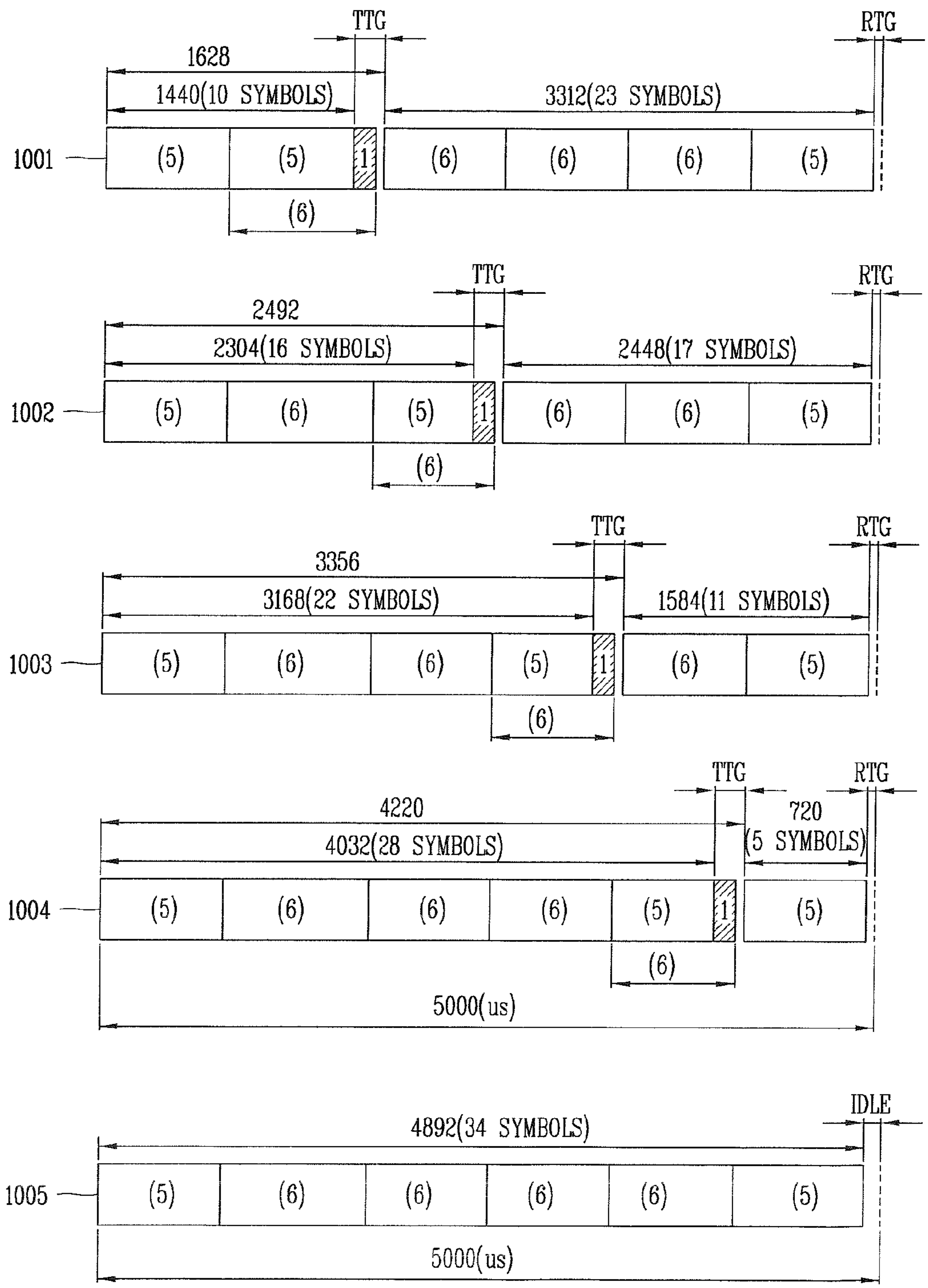
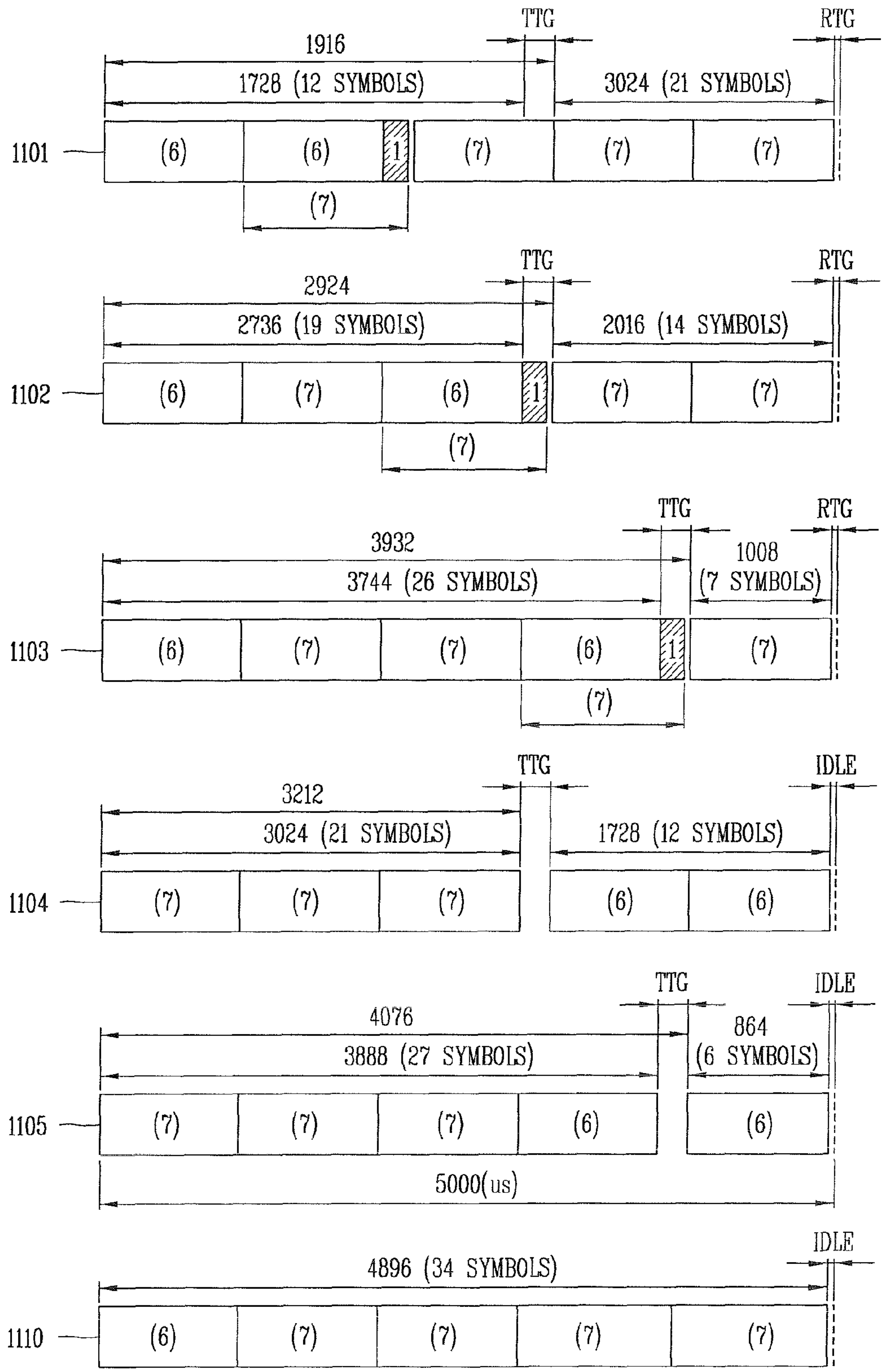

TTG
RTG
1628
1440(10 SYMBOLS)
3312(23 SYMBOLS)
1001
(5)
(5)
1
(6)
(6)
(6)
(5)
(6)
TTG
RTG
2492
2304(16 SYMBOLS)
2448(17 SYMBOLS)
1002
(5)
(6)
(5)
1
(6)
(6)
(5)
(6)
TTG
RTG
3356
3168(22 SYMBOLS)
1584(11 SYMBOLS)
1003
(5)
(6)
(6)
(5)
1
(6)
(5)
(6)
TTG
RTG
4220
720
4032(28 SYMBOLS)
(5 SYMBOLS)
1004
(5)
(6)
(6)
(6)
(5)
1
(5)
(6)
5000(us)
IDLE
4892(34 SYMBOLS)
1005
(5)
(6)
(6)
(6)
(6)
(5)
5000(us)

FIG. 11



TTG
RTG
1916
1728 (12 SYMBOLS)
3024 (21 SYMBOLS)
1101
(6)
(6)
1
(7)
(7)
(7)
(7)
TTG
RTG
2924
2736 (19 SYMBOLS)
2016 (14 SYMBOLS)
1102
(6)
(7)
(6)
1
(7)
(7)
(7)
TTG
RTG
3932
3744 (26 SYMBOLS)
1008
(7 SYMBOLS)
1103
(6)
(7)
(7)
(6)
1
(7)
(7)
TTG
IDLE
3212
3024 (21 SYMBOLS)
1728 (12 SYMBOLS)
1104
(7)
(7)
(7)
(6)
(6)
TTG
IDLE
4076
3888 (27 SYMBOLS)
864
(6 SYMBOLS)
1105
(7)
(7)
(7)
(6)
(6)
5000(us)
IDLE
4896 (34 SYMBOLS)
1110
(6)
(7)
(7)
(7)
(7)

FIG. 12

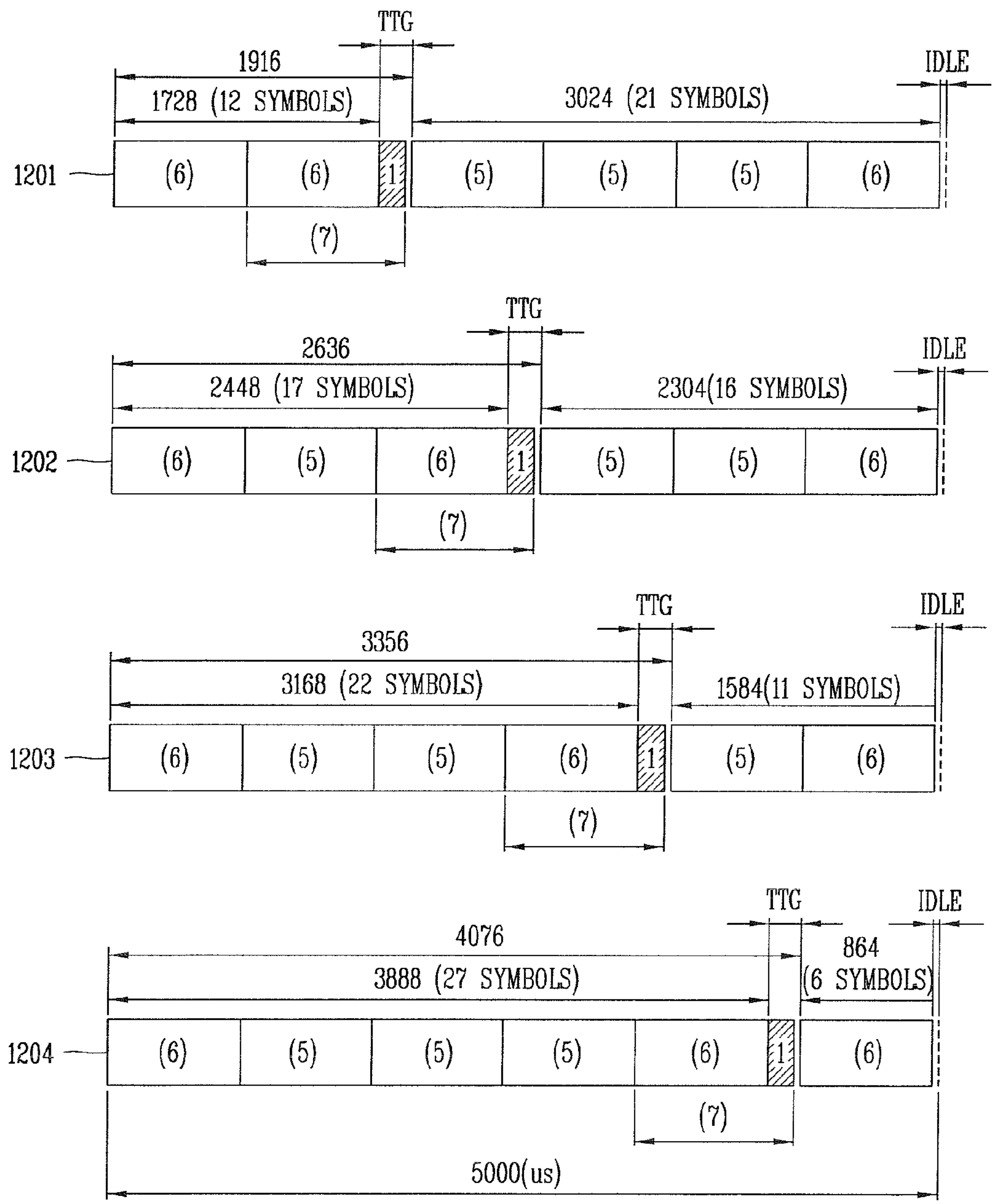

TTG
1916
1728 (12 SYMBOLS)
3024 (21 SYMBOLS)
IDLE
1201
(6)
(6)
1
(5)
(5)
(5)
(6)
(7)
TTG
2636
2448 (17 SYMBOLS)
2304(16 SYMBOLS)
IDLE
1202
(6)
(5)
(6)
1
(5)
(5)
(6)
(7)
TTG
3356
3168 (22 SYMBOLS)
1584(11 SYMBOLS)
IDLE
1203
(6)
(5)
(5)
(6)
1
(5)
(6)
(7)
TTG
IDLE
4076
864
3888 (27 SYMBOLS)
(6 SYMBOLS)
1204
(6)
(5)
(5)
(5)
(6)
1
(6)
(7)
5000(us)

FIG. 13

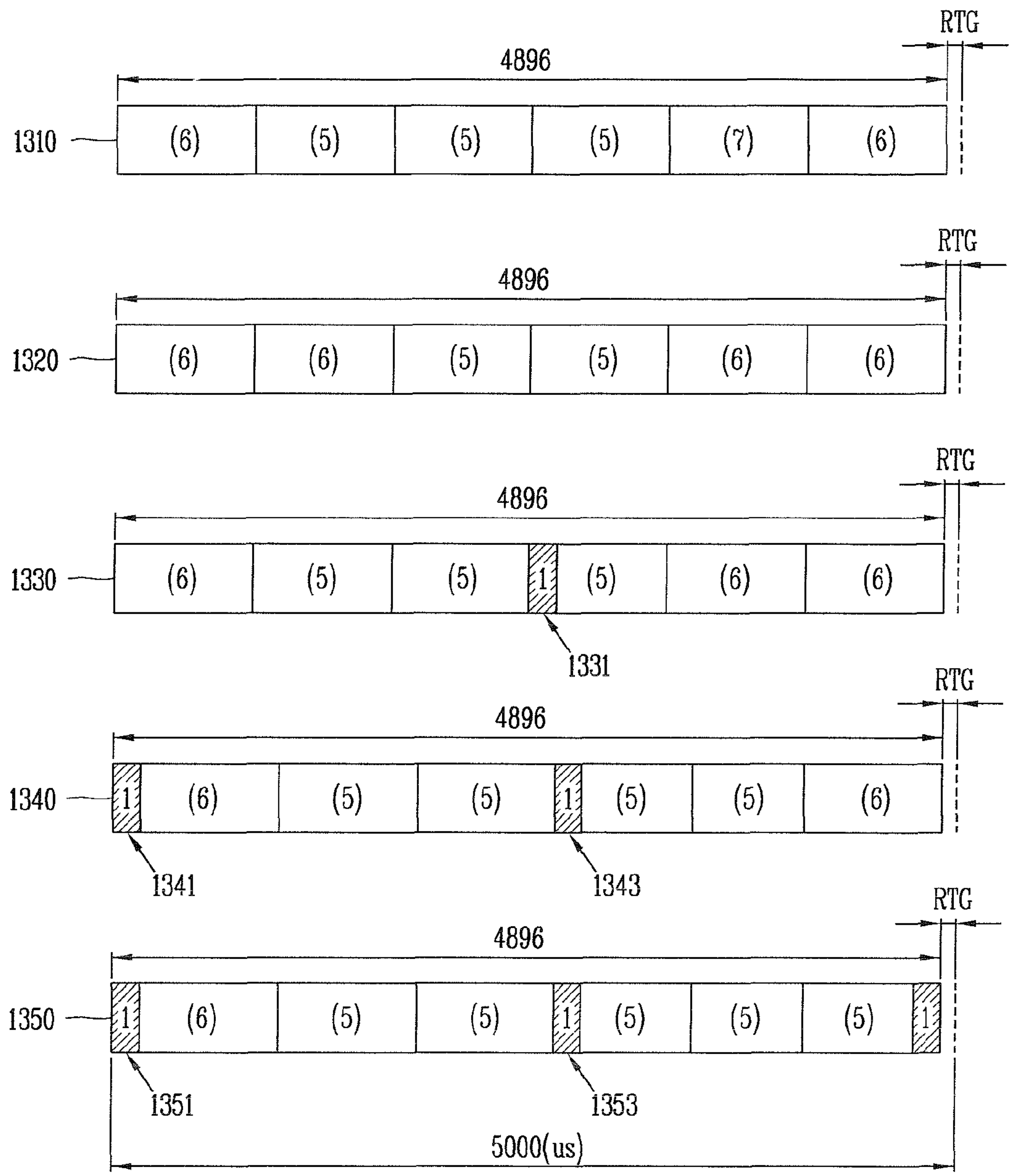

RTG
4896
1310
(6)
(5)
(5)
(5)
(7)
(6)
RTG
4896
1320
(6)
(6)
(5)
(5)
(6)
(6)
RTG
4896
1330
(6)
(5)
(5)
1
(5)
(6)
(6)
1331
RTG
4896
1340
1
(6)
(5)
(5)
1
(5)
(5)
(6)
1341
1343
RTG
4896
1350
1
(6)
(5)
(5)
1
(5)
(5)
(5)
1
1351
1353
5000(us)

FIG. 14

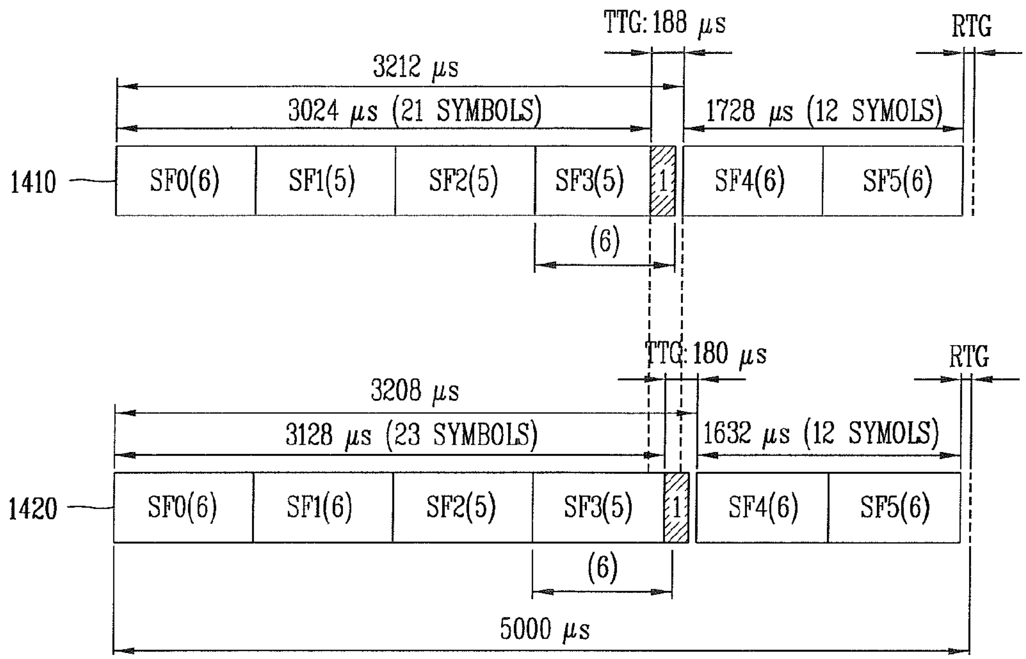

TTG: 188 μs
RTG
3212 μs
3024 μs (21 SYMBOLS)
1728 μs (12 SYMOLS)
1410
SF0(6)
SF1(5)
SF2(5)
SF3(5)
1
SF4(6)
SF5(6)
(6)
TTG: 180 μs
RTG
3208 μs
3128 μs (23 SYMBOLS)
1632 μs (12 SYMOLS)
1420
SF0(6)
SF1(6)
SF2(5)
SF3(5)
1
SF4(6)
SF5(6)
(6)
5000 μs

FIG. 15

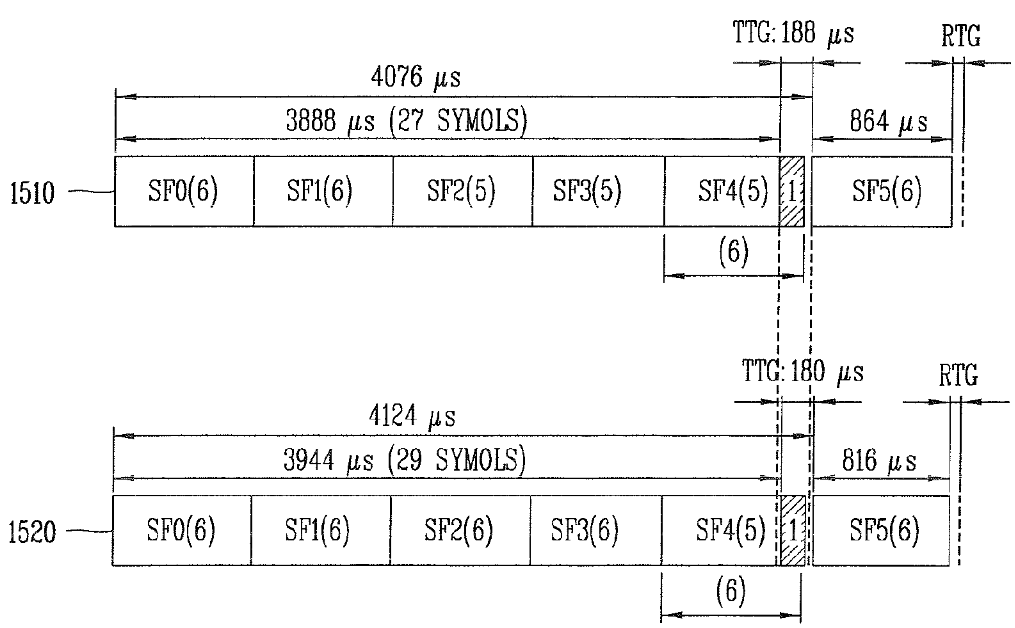

TTG: 188 μs
RTG
4076 μs
3888 μs (27 SYMOLS)
864 μs
1510
SF0(6)
SF1(6)
SF2(5)
SF3(5)
SF4(5)
1
SF5(6)
(6)
TTG: 180 μs
RTG
4124 μs
3944 μs (29 SYMOLS)
816 μs
1520
SF0(6)
SF1(6)
SF2(6)
SF3(6)
SF4(5)
1
SF5(6)
(6)

FIG. 16

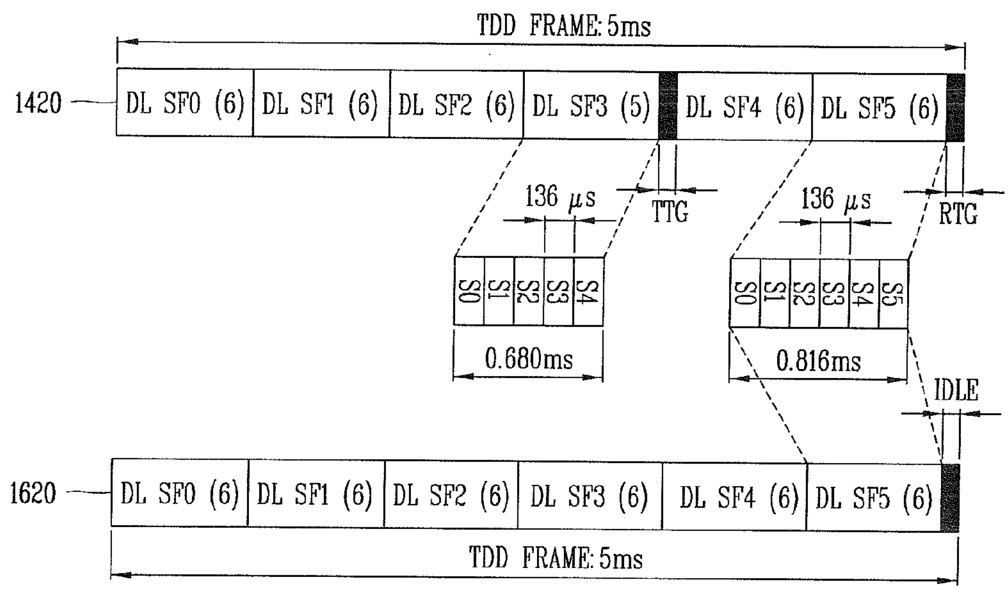
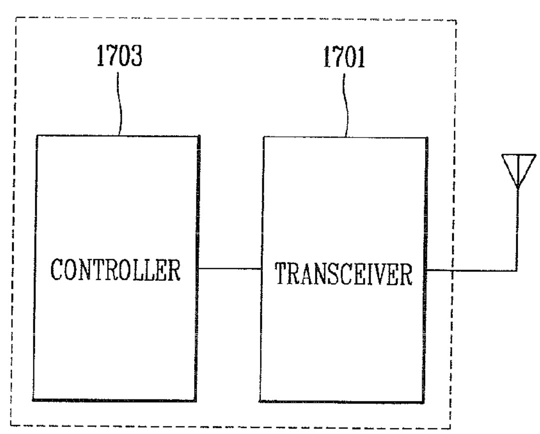

TDD FRAME: 5ms
1420
DL SF0 (6)
DL SF1 (6)
DL SF2 (6)
DL SF3 (5)
DL SF4 (6)
DL SF5 (6)
136 μs
TTG
136 μs
RTG
S0 S1 S2 S3 S4
S0 S1 S2 S3 S4 S5
0.680ms
0.816ms
IDLE
1620
DL SF0 (6)
DL SF1 (6)
DL SF2 (6)
DL SF3 (6)
DL SF4 (6)
DL SF5 (6)
TDD FRAME: 5ms

FIG. 17


1703
1701
CONTROLLER
TRANSCEIVER

METHOD AND APPARATUS FOR DATA TRANSMISSION USING A DATA FRAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the National Stage filing under 35 U.S.C. 371 of International Application No. PCT/KR2009/007646, filed on Dec. 21, 2009, which claims the benefit of earlier filing date and right of priority to Korean Application Nos. 10-2009-0078412, filed on Aug. 24, 2009, and 10-2009-0078413, filed on Aug. 24, 2009, and U.S. Provisional Application Ser. Nos. 61/142,600, filed on Jan. 5, 2009, 61/141,660, filed on Dec. 30, 2008, 61/141,659, filed on Dec. 30, 2008, and 61/140,055, filed on Dec. 22, 2008, the contents of all of which are incorporated by reference herein in their entireties.

TECHNICAL FIELD

The present invention relates to a common frame structure applicable to various bandwidths and a method and apparatus for transmitting and receiving data using the same.

BACKGROUND ART

In line with a communication technique, services provided by a mobile communication system is growingly evolving into diversification of a packet data transmission/reception service for transmitting a large quantity of data, a multimedia broadcast service, and the like, as well as a voice communication service.

A third-generation communication service such as WCDMA, currently on service, allows for a transmission and reception of a large quantity of data, as well as voice data, at a high transfer rate, and in order to create an evolved network having a broader bandwidth in consideration of an anticipated rapid increase in data traffic, standardizations of a long-term evolution (LTE) network, IEEE802.16m, and the like, are being actively ongoing.

In particular, the IEEE 802.16m is aimed at developing a standard that can satisfy the requirements of an IMT-Advanced system while maintaining compatibility with the existing 802.16 standard-based terminal (or user equipment) and base station equipment.

The thusly evolved IMT-Advanced communication system is a broadband wireless access communication system, featuring that it has an extensive service area and supports a fast transfer rate. In order to support a broadband transmission network at a physical channel, the broadband wireless access communication system employs orthogonal frequency division multiplexing (OFDM) and orthogonal frequency division multiplexing access (OFDMA). In the OFDM/OFDMA schemes, a physical channel signal is transmitted and received by using a plurality of subcarriers, thus enabling high speed data communication.

FIG. **1** illustrates an uplink (UL) and downlink (DL) frame structure of a broadband wireless access communication system employing the OFDM/OFDMA schemes.

With reference to FIG. **1**, the uplink and downlink frame structure includes areas of a preamble **101**, a frame control header (FCH) **102**, a DL-MAP **103**, a UL-MAP **104**, and a plurality of data burst areas.

A preamble sequence, a synchronous signal, for acquiring mutual synchronization between the base station and the terminal is transmitted through the preamble **101** area, channel allocation information and channel code information related to the DL-MAP **103** are provided through the FCH **102** area, and channel allocation information of a data burst in downlink and uplink is provided through the DL/UL-MAP **103** and **104** area. A guard time for discriminating the frames is inserted between an uplink frame and a downlink frame. A TTG (Transmit/received Transition Gap) is a guard time between downlink bursts and subsequent uplink bursts. An RTG (Receive/transmit Transition Gap) is a guard time between the uplink bursts and subsequent downlink bursts.

The IMT-Advanced system is required to support various bandwidths, and in particular, IEEE802.16m, whose standardization is currently proceeding, defines bandwidths such as 5 MHz, 7 MHz, 8.75 MHz, 10 MHz, 20 MHz, etc., as bandwidths of a system channel. However, currently, the IMT-Advanced system does not define a substantial frame structure, and in particular, in case of IEEE802.16m, if frames are individually designed for the respective bandwidths, the system complexity would increase. In addition, the frame structure differs when the length of the cyclic prefix (CP) of the frame is variably configured, and in this case, when a single communication system uses both frame structures each having a different CP length, a problem arises in that the interference between neighboring cells occurs.

TECHNICAL GIST OF THE PRESENT INVENTION

Therefore, it is an object of the present invention to provide a frame structure that can be commonly applicable to various bandwidths required by a system, and a method and apparatus for transmitting and receiving data through the frame structure.

To achieve the above object, there is provided a method for transmitting data in a broadband wireless communication system, including: setting a data frame for transmitting and receiving data through uplink and downlink; and transmitting and receiving data through the set data frame, wherein the data frame includes one or more first subframes and one or more second subframes including a different number of data symbols from that of data symbols of the first subframe.

The first subframe may be configured to include six data symbols as one unit, the second subframe may be configured to include five data symbols as one unit, and the data frame may be configured such that the number of the first subframes is maximized.

To achieve the above object, there is also provided an apparatus for transmitting and receiving data, including: a transceiver configured to transmit and receive data through downlink and uplink; and a controller configured to set a data frame including one or more first subframes and one or more second subframes including a different number of data symbols from that of data symbols of the first subframe and control the transceiver to transmit and receive data through the set data frame, wherein the controller configures the data frame such that the number of the first subframes is maximized.

To achieve the above object, there is also provided a method for transmitting data in a time division duplex (TDD) type orthogonal frequency division multiplexing access (OSDMA) communication system, including: setting a data frame including a plurality of subframes; and transmitting data through the set data frame, wherein the cyclic prefix (CP) of the data frame is $1/16$ of the length of a valid OFDMA symbol, the bandwidth of a transport channel is 7 MHz, and the data frame is configured such that the number of subframes configured to include six data symbols as one unit is maximized.

The ratio of the subframes of the downlink and uplink of the data frame may be K:J, the number of data symbols allocated to the downlink may be 6*K−1, the number of data symbols allocated to the uplink may be 6*J, one data symbol may be allocated to TTG (Transmit/receive Transition Gap), and the last subframe of the downlink may be configured to include five symbols as one unit.

The ratio of the subframes of the downlink and uplink of the data frame may be 5:1, first to fourth subframes of the downlink and subframes of the uplink may be configured to include six symbols as one unit, and the fifth subframe of the downlink may be configured to include five symbols as one unit.

To achieve the above object, there is also provided a method for transmitting data in a frequency division duplex (FDD) type orthogonal frequency division multiplexing access (OSDMA) communication system, including: setting a data frame including a plurality of subframes; and transmitting data through the set data frame, wherein the cyclic prefix (CP) of the data frame is 1/16 of the length of a valid OFDMA symbol, a bandwidth of a transport channel is 7 MHz, and the data frame is configured to include only subframes including six data symbols as one unit.

To achieve the above object, there is also provided an apparatus for transmitting and receiving data, including: a transceiver configured to transmit and receive data through downlink and uplink; and a controller configured to set a data frame including one or more subframes having n number of data symbols and control the transceiver to transmit and receive data through the set data frame, wherein the controller configures the data frame such that the number of the subframes is maximized.

The cyclic prefix (CP) of the data frame may be 1/16 of the length of a valid OFDM symbol, the bandwidth of a transport channel may be 7 MHz, and the data symbol unit 'n' of the subframe may be 6.

According to exemplary embodiments of the present invention, a frame structure that can be commonly applicable to a system required to support various bandwidth is provided, the problem in that a system complexity increases can be prevented.

In addition, in the TDD type data frame, an interference between downlink and uplink of frames each having a different CP length can be prevented, and an FDD frame having common characteristics as those of the TDD frame structure can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view schematically showing an uplink and downlink frame structure of a broadband wireless access communication system;

FIG. **2** is a view schematically showing an OFDM/OFDMA symbol structure used in an exemplary embodiment of the present invention;

FIG. **3** is a view schematically showing a frame structure of an upper level according to an exemplary embodiment of the present invention;

FIG. **4** is a view schematically showing an FDD type frame structure according to an exemplary embodiment of the present invention;

FIG. **5** is a view schematically showing an TDD type frame structure according to an exemplary embodiment of the present invention;

FIG. **6** is a view showing TDD and FDD frame structures according to another exemplary embodiment of the present invention;

FIG. **7** is a view showing a TDD frame structure according to another exemplary embodiment of the present invention;

FIG. **8** is a view showing a TDD frame structure according to still another exemplary embodiment of the present invention;

FIG. **9** is a view showing an FDD frame structure according to another exemplary embodiment of the present invention;

FIG. **10** is a view showing TDD and FDD frame structures according to still another exemplary embodiment of the present invention;

FIG. **11** is a view showing TDD and FDD frame structures according to yet another exemplary embodiment of the present invention;

FIG. **12** is a view showing an FDD frame structure according to still another exemplary embodiment of the present invention;

FIG. **13** is a view showing an FDD frame structure according to yet another exemplary embodiment of the present invention;

FIG. **14** is a view showing a TDD frame structure according to another exemplary embodiment of the present invention;

FIG. **15** is a view showing a TDD frame structure according to another exemplary embodiment of the present invention;

FIG. **16** is a view showing an FDD frame structure according to another exemplary embodiment of the present invention;

FIG. **17** is a schematic block diagram of an apparatus for transmitting and receiving data according to an exemplary embodiment of the present invention.

MODE FOR CARRYING OUT THE PREFERRED EMBODIMENTS

Exemplary embodiments of the present invention will now be described in detail with reference to the accompanying drawings. The same reference numerals will be used throughout to designate the same or like components and a repeated description will be omitted. In describing the present invention, if a detailed explanation for a related known function or construction is considered to unnecessarily divert the gist of the present invention, such explanation will be omitted but would be understood by those skilled in the art. In the drawings, the shapes and dimensions may be exaggerated for clarity, and the same reference numerals will be used throughout to designate the same or like components. The accompanying drawings, which are given by illustration only, and thus are not limitative of the present invention.

The terminal according to an exemplary embodiment of the present invention may also be referred to as subscriber station (SS), user equipment (UE), mobile equipment (ME), mobile station (MS), and the like. Also, the terminal may be a portable device having a communication function such as a mobile phone, a PDA, a smartphone, a notebook, and the like, or a non-portable device such as a PC or a vehicle-mounted device.

FIG. **2** is a view schematically showing an OFDM/OFDMA symbol structure used in an exemplary embodiment of the present invention.

In the OFDM/OFDMA scheme, a certain interval before each symbol is used as a guard interval which is not in use in consideration of the influence of an inter-symbol interface (ISI) due to a reflective wave, and as illustrated, a portion of the rear of a symbol is duplicated as the guard interval and inserted. The front portion of the symbol inserted in the guard interval is called a cyclic prefix (CP).

When the overall length of one OFDM symbol is Ts and the length of the CP is Tg, the length of the valid OFDM symbol is Tb obtained by excluding the length of CP from the overall length of the OFDM symbol Ts.

As for the frame structure configured as the OFDM/OFDMA symbol, the frame size and the number of subframes and symbols may be determined according to frame parameters as shown in Table 1 below:

TABLE 1

Nominal Channel Bandwidth (MHz)			5	7	8.75	10	20
Over-sampling Factor			28/25	8/7	8/7	28/25	28/25
Sampling Frequency (MHz)			5.6	8	10	11.2	22.4
FFT size			512	1024	1024	1024	2048
Sub-Carrier Spacing (KHz)			10.937500	7.812500	9.765625	10.937500	10.937500
Useful symbol Time Ts (μs)			91.429	128	102.4	91.429	91.429
Cyclic Prefix (CP) $T_g = 1/8\ T_u$	Symbol Time T_s (μs)		102.857	144	115.2	102.857	102.857
	FDD	Number of OFDM symbols per Frame	48	34	43	48	48
		Idle time (μs)	62.857	104	46.40	62.857	62.857
	TDD	Number of OFDM symbols per Frame	47	33	42	47	47
		TTG + RTG (μs)	165.714	248	161.6	165.714	165.714
Cyclic Prefix (CP) $T_g = 1/16\ T_u$	Symbol Time T_s (μs)		97.143	136	108.8	97.143	97.143
	FDD	Number of OFDM symbols per Frame	51	36	45	51	51
		Idle time (μs)	45.71	104	104	45.71	45.71
	TDD	Number of OFDM symbols per Frame	50	35	44	50	50
		TTG + RTG (μs)	142.853	240	212.8	142.853	142.853
Cyclic Prefix (CP) $T_g = 1/4\ T_u$	Symbol Time T_s (μs)		114.286	160	128	114.286	114.286
	FDD	Number of OFDM symbols per Frame	43	31	39	43	43
		Idle time (μs)	85.694	40	8	85.694	85.694
	TDD	Number of OFDM symbols per Frame	42	30	38	42	42
		TTG + RTG (μs)	199.98	200	136	199.98	199.98

When a transport channel band and a CP length of the system are determined with reference to Table 1, the number of OFDM symbols and other required parameters for designing a frame can be determined.

The frame structure will now be described in detail with reference to the accompanying drawings.

FIG. **3** is a view schematically showing a frame structure of an upper level according to an exemplary embodiment of the present invention.

As illustrated in FIG. **3**, the frame structure applied to the system according to an exemplary embodiment of the present invention is includes 5-ms frame as a basic element, and the frame, which is a basic single transmission unit, may be defined as an interval between preambles.

The frame may include a plurality of TTI (Transmission Time Interval), and the TTI is a basic unit of scheduling performed in a MAC (Medium Access Control) layer, and also a radio resource allocation unit.

A frame includes at least one subframe, and the size of a subframe is determined by symbols. In an exemplary embodiment of the present invention, subframes are defined as a total four types of subframes: Type-1, Type-2, Type-3, and Type-4. The Type-1 subframe includes six OFDM symbols. The Type-2 subframe includes seven OFDM symbols. The Type-3 subframe includes five OFDM symbols. The Type-4 subframe includes nine OFDM symbols.

As shown, a superframe including a plurality of frames are formed, and in this case, the superframe may be configured by, for example, 20 ms. When the superframe is configured, system configuration information for an initial fast cell selection and low latency service its transmission unit and broadcast information are set as transmission units, and in general, two to six frames are configured as a single superframe. Also, a single frame by 5 ms includes a plurality of subframes, and each subframe includes a plurality of OFDM/OFDMA symbols. Each superframe includes one superframe header (SFH) including a broadcast channel, and the SFH is positioned at a first downlink (DL) subframe of the corresponding superframe.

The frame structure may be designed according to the bandwidth of a system channel, a duplex scheme, a CP length, and the like.

FIG. **4** is a view schematically showing an FDD type frame structure according to an exemplary embodiment of the present invention.

In an FDD mode, downlink and uplink transmissions are discriminated on a frequency domain, and every subframe of each frame may be transmitted via uplink and downlink. A terminal in the FDD mode may receive a data burst with a certain downlink subframe while accessing an uplink subframe simultaneously.

FIG. **4** defines a frame structure in the FDD mode when channel bandwidths are 5 MHz, 10 MHz, and 20 MHz and a CP length is ⅛ Tb. 20 ms superframe includes four 5 ms frames F**0**, Fl, F**2**, and F**3**, and one frame F**2** includes eight subframes SF**0**, SF**1**, SF**2**, SF**3**, SF**4**, SF**5**, SF**6**, and SF**7** each having a length of 0.617 ms and an idle time interval of 62.86 μs. Each subframe is configured as a Type-2 subframe including seven OFDM symbols S**0**, S**1**, S**2**, S**3**, S**4**, S**5**, and S**6**.

FIG. **5** is a view schematically showing an TDD type frame structure according to an exemplary embodiment of the present invention.

In a TDD mode, downlink and uplink transmissions are discriminated on a time domain. As an uplink transmission time interval is allocated after a downlink transmission time interval, data is transmitted or received via downlink or uplink.

Likewise as in FIG. **4**, in FIG. **5**, a TDD mode frame structure is defined when channel bandwidths are 5 MHz, 10 MHz, and 20 MHz and a CP length is ⅛ Tb. 20 ms superframe includes four 5 ms frames F**0**, F**1**, F**2**, and F**3**, and one frame F**2** includes eight subframes SF**0**, SF**1**, SF**2**, SF**3**, SF**4**, SF**5**, SF**6**, and SF**7** each having a length of 0.617 ms and an idle time interval of 62.86 μs. The frame F**2** includes D number of continuous downlink frames and U number of continuous uplink frames determined according to the ratio of downlink and uplink (D:U). When the ratio of DL and UL is 5:3, five subframes SF**0**, SF**1**, SF**2**, SF**3** and SF**4** are configured as DL frames, and three subframes SF**5**, SF**6**, and SF**7** are configured as uplink frames. A single idle symbol for discriminating the DL and UL is inserted between the last downlink subframe SF**4** and the first uplink subframe SF**5** to inform about switching from DL to UL. The gap inserted between the downlink and uplink is called a TTG (Transmit Transition Gap) and the gap inserted between the uplink and downlink and uplink is called an RTG (Receive Transition Gap), by which a transmission end and a reception end can discriminate a downlink transmission and an uplink transmission.

As shown in FIG. **5**, the last downlink subframe SF**4** includes five OFDM symbols and the last one idle symbol S**5**, and in this case, the idle symbol S**5** serves as a TTG discriminating the DL and the UL.

FIG. **6** is a view showing TDD and FDD frame structures according to another exemplary embodiment of the present invention.

The frame structure illustrated in FIG. **6** is a case where it is assumed that a CP length is 1/16 Tb and transport channel bandwidths are 5 MHz, 10 MHz, and 20 MHz. In case of the TDD frame, it is assumed that the ratio of DL and UL is 5;3 and the length of the TDD/FDD frame is basically 5 ms. The number of OFDM symbols within one frame (TDD frame or FDD frame) is a total of 48, and one frame includes a total of eight subframes. Thus, unlike the case illustrated in FIGS. **4** and **5**, the subframes cannot be all configured as the same type. Namely, the subframes are configured as a Type-1 subframe **610** including six OFDM symbols and a Type-2 subframe **620** including seven OFDM symbols.

The Type-1 subframe **610** includes six OFDM symbols and has a length of 0.583 ms. The Type-2 subframe **620** includes seven OFDM symbols and has a length of 0.680 ms. The TDD frame and the FDD frame have the same size and same subframe configuration, but in case of the TDD frame, because a TTG is required between the DL and UL, the last symbol of the fifth subframe SF**4** is configured as an idle symbol **611**.

As described above, in the channel bandwidths of 5 MHz, 10 MHz, and 20 MHz, the frame structure is configured such that the Type-1 subframe including six symbols is a basic subframe and also configured such that the number of basic subframes (Type-1 subframes) is maximized. Because the frame structure is configured such that the number of the basic subframes is maximized, when data is transmitted and received b using frames between the transmission end and the reception end, the minimum size of the TTI, the basic unit, is the subframe, so the same configuration and design of the pilot and resource block of the physical layer (PHY) can be used to its maximum level.

Hereinafter, the TDD and FDD frame structures when the channel bandwidth is 7 MHz and a CP length is ⅛ Tb will now be described.

FIG. **7** is a view showing a TDD frame structure according to another exemplary embodiment of the present invention.

With reference to Table 1, 34 OFDM symbols are available for the bandwidth of 7 MHz and ⅛ Tb. In the basic frame structure of 5 MHz, 10 MHz, and 20 MHz, the Type-1 subframe including six symbols is used as the basic subframe, and the present exemplary embodiment proposes the frame structure using the Type-1 subframes including six symbols as many as possible. In FIG. **7**, one frame includes six subframes, and the Type-1 subframe including six symbols is used as many as possible, 30 symbols (6*5) can be configured and four symbols remain. In the TDD structure, when one symbols is left for a TTG, three symbols remain, so a subframe including three symbol units can be configured. The subframe including three symbol units is defined as a mini-subframe. The structure of the physical layer (PHY) for the Type-1 subframe including six symbols can be discriminated by three symbols, so when the mini-subframe is configured, a portion of the existing PHY structure can be utilized. Alternatively, a Type-4 subframe including nine symbols can be configured by combining the mini-subframe with the Type-1 subframe including six symbols. When a frame is configured with the Type-4 subframes, it can be configured in the frame structures **720**, **730** and **740**, excluding the frame structure **710** in FIG. **7**.

In the TDD mode, the first subframe is used as the super frame header (SFH), so preferably, the Type-1 subframe including six symbols is configured as the first subframe of the frame. Thus, as illustrated, the ratio of DL and UL available in the TDD mode may include the four types of frames **710**, **720**, **730**, and **740** as 2:4, 3:3, 4:2, and 5:1.

Among them, the last subframe of DL is configured as the mini-subframe including three symbols as described above, and the last one symbol is allocated for a TTG.

FIG. **8** is a view showing a TDD frame structure according to still another exemplary embodiment of the present invention.

Compared with the exemplary embodiment of FIG. **7** as described above, when the ratio of DL and UL is 4:2 and 5:1, a TDD frame is configured based on the Type-3 subframe including five symbols. In the present exemplary embodiment, when the radio of DL and UL is 2:4, and 3:3, the structure illustrated in FIG. **7** can be used as it is. Thus, a description thereof will be omitted and the case in which the ratio of DL and UL is 4:2 and 5:1 will be described.

As for a TDD frame **830** having a ratio of DL and UL of 4:2, in consideration of the fact that the first subframe is used for the SFH in the TDD mode, the first subframe is configured as the Type-1 basic subframe SF**0** including six symbols, the second and third subframes SF**1** and SF**2** are configured as the Type-3 subframes including five symbols, and the fourth DL subframe SF**3** includes a symbol for a TTG, resulting in formation of a Type-3 subframe substantially configured by five symbol units. Thus, the UL subframes SF**4** and SF**5** are configured as basic subframes of the Type-1 each having six symbols.

As for a TDD frame **840** having a ratio of DL and UL of 5:1, likewise, in consideration of the fact that the first subframe is used for the SFH in the TDD mode, the first subframe is configured as the Type-1 basic subframe SF**0** including six symbols, the third and fourth subframes SF**1** and SF**2** are configured as the Type-3 subframes including five symbols, and the fifth DL subframe SF**3** includes a symbol for a TTG, resulting in formation of a Type-3 subframe substantially configured by five symbol units. The UL subframe SF**5** is configured as the Type-1 subframe having six symbols. Through such structures, basically, a frame can be configured such that includes the number of Type-1 subframes including six symbols is maximized.

FIG. **9** is a view showing an FDD frame structure according to another exemplary embodiment of the present invention.

In the present exemplary embodiment, the Type-1 subframe including six symbols are used as the basic subframe, based on which a frame is configured such that the number of the Type-1 subframes is maximized, and one mini-subframe is added to configured an FDD frame. In case of the FDD frame, unlike the TDD frame, the FDD frame does not need a gap used as the TTG/RTG, so one symbol can be additionally allocated in the frame besides the basic subframes and the mini-subframe.

Referring to the first and second FDD frames **910** and **920**, remaining one symbol is added to the mini-subframes SF**3** and SF**5** to configure the extended mini-subframes SF**3** and SF**5** including four symbols. The mini-subframes are not limited to the case illustrated in the drawing and also are not limited in its disposition within the frame.

Like the embodiments of **930**, **940**, and **950** of the FDD frames, one symbol may be inserted in the frame, and a mini-subframe including three symbols may be configured at the end of the frame. In this configuration, the structure of the physical layer (PHY) can be utilized as much as possible by actively using the mini-subframes including three symbols as described above. The remaining one symbol may be positioned behind the second or third subframe, the middle of the frame, or may be positioned at the forefront of the frame so as to be utilized for a transmission of control information by symbol, e.g., additional information such as a preamble and FCH.

In a different exemplary embodiment, the mini-subframe may be combined with the Type-1 subframe including six symbols to configure the Type-4 subframe including nine symbols. When a frame is configured with the Type-4 subframe, the subframe is the Type-4 subframe including nine symbols as the Type-1 subframe SF**4** and the mini-subframe SF**5** are combined in the frame structures **930**, **940**, and **950** in FIG. **9**.

FIG. **10** is a view showing TDD and FDD frame structures according to still another exemplary embodiment of the present invention.

As shown in FIG. **10**, in the present exemplary embodiment, among thirty-four symbols constituting one frame, ten symbols are configured as the Type-3 subframes including five symbols and the other remaining twenty-four symbols are configured as the Type-1 subframes including six symbol units. Thus, the Type-3 subframes including six symbol units is a basic subframe unit, so four Type-3 subframes are included in one frame, and two Type-3 subframes including five symbol units are configured, thus obtaining a frame structure in which the number of basic subframes is maximized.

In case of configuring TDD frames **1001**, **1002**, **1003**, and **1004**, one symbol is allocated to the TTG interval, so substantially three Type-3 subframes including five symbol units are configured. This is similar to the frame structure in which the CP length is 1/16 Tb in the bands of 5 MHz, 10 MHz, and 20 MHz. Thus, one Type-3 subframe is allocated to DL and UL, respectively and additionally allocated to the last subframe utilized as the TTG, while a maximum number of Type-1 subframe are configured.

In case of configuring the FDD frame **1005** based on the Type-1 subframe, the FDD frame **1005** includes two Type-3 subframes and four Type-1 subframes by adding one symbol compared with the above-described TDD frames **1001**, **1002**, **1003**, and **1004**. The Type-3 subframe may be positioned at the forefront or back as illustrated, but the present invention is not limited thereto.

FIG. **11** is a view showing TDD and FDD frame structures according to yet another exemplary embodiment of the present invention.

In the present exemplary embodiment, a frame is configured based on the Type-2 subframe including seven symbol units.

Among thirty-four symbols constituting one frame, four subframes are configured as the Type-2 subframe including seven symbols, and the other remaining one subframe is configured as the Type-1 subframe including six symbols. In this respect, because one symbol can be utilized as the TTG in the TDD frames **1101**, **1102**, and **1103**, one symbol of the Type-2 subframe is utilized as the TTG and the corresponding subframe is changed to the Type-1 subframe. The TDD frames **1101**, **1102**, and **1103** features that a frame can be configured only two types of subframes such as the frame structure in the bands of 5 MHz, 10 MHz, and 20 MHz and the existing physical layer (PHY) structure can be utilized in the same manner. Also, the TDD frames have structural features in that the Type-2 subframe can be changed to the Type-1 subframe due to one symbol utilized as the TTG interval so as to be transmitted.

The ratio of DL and UL considered in the TDD frames **1101**, **1102**, and **1103** is defined as 2:3, 3:2, and 4:1, and the basic subframe may be positioned at the forefront in terms of unification of the size of the SFH, whereby the basic subframe may not be affected by the ratio of the DL and UL.

In addition, when the radio of the DL and UL in the TDD frames **1104** and **1105** is 3:2 and 4:1, the number of symbols of the UL is adjusted by the multiple unit of 6. This is desirous in terms of a legacy support, and thus, the available DL:UL ratio is 3:2 and 4:1. According to circumstances, the TDD frame **1105** in which one subframe of DL is configured a subframe including six symbols and one independent is configured in consideration of the position of the SFH.

The FDD frame **1110** may be configured by using the Type-2 subframe including seven symbol units. Preferably, the first subframe is configured as the Type-1 subframe including six symbols in order to use a SFH design and common characteristics of the different bandwidths (5 MHz, 10 MHz, and 20 MHz). However, the position of the Type-1 subframe is not limited thereto and may be freely disposed in the frame.

FIG. **12** is a view showing an FDD frame structure according to still another exemplary embodiment of the present invention.

In the present exemplary embodiment, a frame is configured based on the Type-3 subframe including five symbol units. Namely, among thirty-four symbols constituting one frame, fifteen symbols are used to configure three Type-3 subframes and twelve symbols are used to configure two Type-1 subframes and the other remaining seven symbols used to configure Type-2 subframes.

One symbol can be utilized for the TTG in the TDD mode, so the last subframe of the DL related to the TTG interval can be changed to a different subframe type. For example, in the case in which the Type-2 subframe including seven symbol units is disposed as the last subframe of the DL, the Type-2 subframe is changed into the Type-1 subframe due to the TTG interval. In case in which the Type-1 subframe is disposed as the last subframe of the DL, the Type-1 subframe is changed into the Type-3 subframe having five symbol units.

The other remaining matters related to the frame configuration are the same as those described in the above exemplary embodiments, so its detailed description will be omitted.

FIG. **13** is a view showing an FDD frame structure according to yet another exemplary embodiment of the present invention.

In the present exemplary embodiment, an FDD frame is configured based on the Type-3 subframe, likewise as in the case illustrated in FIG. **12**. A first FDD frame **1310** includes one additional symbol compared with the TDD frame **1204** illustrated in FIG. **12** because it does not require a TTG, and the additional symbol changes the single Type-1 subframe into the Type-2 subframe.

Likewise, a second FDD frame **1320** includes one additional symbol compared with the TDD frame **840** illustrated in FIG. **8** because it does not require a TTG, and the additional symbol changes the single Type-3 subframe into the Type-1 subframe. Thus, the FDD frame **1320** includes a total of four Type-1 subframes and two Type-3 subframes. The position of the Type-3 subframe is not limited thereto and may be freely modified.

Also, like a third FDD frame **1330**, one symbol **1331** may be separated, and the other remaining symbols may be used to configure three Type-1 subframes and three Type-3 subframes. In this case, the position of the separated symbol **1331** is not limited thereto.

Also, like a fourth FDD frame **1340**, two symbols **1341** and **1343** may be separated, and like another FDD frame **1350**, three symbols **1351**, **1353**, and **1355** may be separated. The symbols **1331**, **1341**, **1343**, **1351**, **1353**, and **1355** independently configured in the FDD frames **1330**, **1340**, and **1350** may be used for transmitting control information in units of symbols, for example, additional information such as a preamble or an FCH.

Hereinafter, a TDD frame structure when a channel bandwidth is 7 MHz and a CP length is 1/16 Tb will be described.

FIG. **14** is a view showing a TDD frame structure according to another exemplary embodiment of the present invention. The TDD frame structure has a CP length of 1/16 Tb compared with the case where the CP length is 1/8 Tb as described above.

With reference to Table 1, when a frame transport channel bandwidth is 7 MHz, thirty-four OFDM symbols are available for the CP length 1/8 Tb, and thirty-six OFDM symbols are available for the CP length of 1/16 Tb.

In the basic frame structure in the 5 MHz, 10 MHz, and 20 MHz channel transport bands as described above, the Type-1 subframe size including six symbol units is used as the basic subframe, and the present exemplary embodiment also proposes the structure in which the Type-1 subframe including six symbol units is used as the basic subframe and used as many as possible in consideration of a legacy support.

First, in the case of a TDD frame 1410 having a CP length of 1/8 Tb, when the ratio of DL and UL is 4:2, in consideration of the fact that the first subframe is used for the SFH in the TDD mode, the first subframe is configured as the Type-1 basic subframe SF**0** including six symbols, the second and third subframes SF**1** and SF**2** are configured as the Type-3 subframes including five symbols, and the fourth DL subframe SF**3** uses the structure of the Type-1 subframe but the last one symbol is allocated as a TTG symbol between the DL and the UL, resulting in that the fourth subframe is changed into the Type-3 subframe including five symbols. The UL subframes SF**4** and SF**5** are configured as the Type-1 subframes including six symbol units. Through the foregoing structure, a frame can be basically configured to have the basic subframes including six symbol units as many as possible, and accordingly, a frame having commonness with the frame structure of a different channel transport band can be configured in the 7 MHz channel transport band, through which data can be transmitted and received.

In the case of a TDD frame 1420 having a CP length of 1/16 Tb, likewise as above described, the basic subframe is configured as the Type-1 subframe having six symbol units, and a frame is configured is configured such that the number of the basic subframes is maximized. Thus, as illustrated, the Type-1 subframe including six symbol units, excluding the last subframe SF**3**, is configured,. In the last subframe SF**3** of DL, one symbol is allocated for the TTG, so the last subframe SF**3** is configured as the Type-3 subframe having five symbols.

Also, as described above, in order to prevent interference in consideration of an environment in which the TDD frame **1410** structure having the CP length of 1/8 Tb and the frame **1420** structure having the CP length of 1/16 Tb coexist, the TDD frame structure must be designed such that the boundaries of the DL and the UL between the TDD frames **1410** and **1420** having different CP lengths do not overlap with each other.

In the case of the TDD frame **1420** having the CP length of 1/16 Tb, in order to prevent a generation of an interference at the boundary of the DL and UL of the TDD frame having the CP length of 1/8 Tb, $6*k-1$ number of OFDM symbols are allocated to the DL and $6*j$ number of OFDM symbols are allocated to the UL. In the illustrated example, k is 4 and j is 2. Also, with reference to the comparison between the two frames illustrated in FIG. **14**, it is noted that the boundaries of the DL and UL do not overlap with each other.

In comparison between the two frames **1410** and **1420** based on the number of allocated symbols, the number of symbols within the TDD frame **1410** of 1/8 Tb is 34 (21 symbols for DL, one symbol for TTG and 12 symbols for UL), while the number of symbols within the frame **1420** of 1/16 Tb is 36 ($6*k-1=23$ symbols for DL, one symbol for TTG, and $6*j=12$ symbols for UL). Thus, when the TDD frame in the 1/16 Tb is designed based on the TDD frame **710** of 1/8 Tb, the remaining two OFDM symbols, compared with the number of symbols of the TDD frame **1410** of 1/8 Tb, is allocated to the two subframes (SF**1** and SF**2**) including five symbols. Then, one data frame **1420** includes six Type-1 subframes including six symbols. Also, as described above, the last symbol of the DL is allocated for the TTG.

FIG. **15** is a view showing a TDD frame structure according to another exemplary embodiment of the present invention.

As for a TDD frame **1510** having a CP length of $\frac{1}{8}$ Tb, because the overall symbol number is 34, when four Type-1 subframes including six symbol units are configured and two Type-3 subframes including five symbol units are configured, it can be configured such that the basic subframes including six symbol units are maximized, and accordingly, a frame can be designed such that it has a commonness with a frame structure in a different channel transport band, even in the 7 MHz channel transport band. In the TDD mode, it is preferred that the first subframe is configured as the Type-1 subframe SF**0** including six symbols in consideration of the fact that the first subframe is used for the SFH (Super Frame Header). Also, because the last one symbol of the DL is allocated as the TTG symbol between the DL and the UL, when the last subframe of the DL is configured as the Type-1 subframe including six symbol units and the last one symbol is allocated for the TTG, the Type-1 subframe is changed into the Type-3 subframe SF**4** including five symbol units.

In the case of a TDD frame **1520** having a CP length of $\frac{1}{16}$ Tb, likewise as above described with reference to FIG. **14**, the basic subframe is configured as the Type-1 subframe having six symbol units, and a frame is configured is configured such that the number of the basic subframes is maximized. Thus, as illustrated, the basic subframe including six symbol units, excluding the last subframe SF**4**, is configured. In the last subframe SF**4** of DL, one symbol is allocated for the TTG, so the last subframe SF**4** is configured as the Type-3 subframe having five symbols.

Also, as described above, in order to prevent interference in consideration of an environment in which the TDD frame **1510** structure having the CP length of $\frac{1}{8}$ Tb and the frame **1520** structure having the CP length of $\frac{1}{16}$ Tb coexist, the TDD frame structure must be designed such that the boundaries of the DL and the UL between the TDD frames **1510** and **1520** having different CP lengths do not overlap with each other.

As illustrated, In the case of the TDD frame 1520 having the CP length of $\frac{1}{16}$ Tb, in order to prevent a generation of an interference at the boundary of the DL and UL of the TDD frame having the CP length of $\frac{1}{8}$ Tb, $6*k-1$ number of OFDM symbols are allocated to the DL and $6*j$ number of OFDM symbols are allocated to the UL. In the illustrated example, k is 5 and j is 1.

FIG. **16** is a view showing an FDD frame structure according to another exemplary embodiment of the present invention.

In the present exemplary embodiment, the FDD frame is designed such that it has commonness with the TDD structure.

Namely, in the FDD, a TTG is not required, so 36 symbols can be all used to configure and dispose six Type-1 subframes each including six symbols. Thus, because the basic subframes by six units are used to be maximized, the PHY structure and MAC structure defined in the existing 5 MHz, 10 MHz, and 20 MHz can be re-used and a system complexity can be reduced.

FIG. **17** is a schematic block diagram of an apparatus for transmitting and receiving data according to an exemplary embodiment of the present invention.

The apparatus for transmitting and receiving data according to an exemplary embodiment of the present invention includes a transceiver **1701** for transmitting and receiving data configured in the form of a frame and a controller **1703** for controlling transmission and reception of data of the transceiver **1701**.

The controller **1703** sets a data frame for transmitting and receiving data via downlink and uplink, and controls the transceiver **1701** to transmit and receive data through the set data frame. The controller **1703** configures the frame described above with reference to FIGS. **3** to **16** according to the FDD or TDD mode to transmit and receive data. Preferably, the data frame set by the controller **1703** includes one or more Type-1 subframes each including six data symbols, one or more Type-2 subframes each including seven data symbols, one or more Type-3 subframes each including five data symbols, and one or more Type-4 subframes each including nine data symbols. A substantial frame is formed with reference to the bandwidth of the transport channels and the system parameters of Table 1. The frame setting by the controller **1703** has been described above, so its description herein will be omitted.

According to another exemplary embodiment of the present invention, the controller **1703** sets a data frame including one or more subframes each including n number of data symbols, and controls the transceiver **1701** to transmit and receive data through the set data frame.

Also, in configuring the data frame, the controller **1703** configures the data frame such that the number of subframes including n number of symbol units is maximized.

Preferably, the data frame is configured such that basic subframes including six data symbols are maximized, and a substantial frame is formed with reference to the bandwidth of the transport channels and the system parameters of Table 1.

The methods according to the present invention described thus far can be implemented as software, hardware or their combination. For example, the method according to the present invention may be stored in a storage medium (e.g., an internal memory of a terminal, a flash memory, a hard disk, and the like), and may be implemented as codes or commands in a software program that can be executed by a processor (e.g., a microprocessor within a terminal).

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

The invention claimed is:

1. A method for transceiving signals using a predetermined frame structure in a broadband wireless communication system, the method comprising:

configuring, by a controller, a Time Division Duplex (TDD) frame according to the predetermined frame structure, the TDD frame having a channel bandwidth of 7 MHz, and controlling transmission and receipt of data through the TDD frame; and

transceiving a signal through the TDD frame according to the predetermined frame structure,

wherein a Cyclic Prefix length of the TDD frame corresponds to $\frac{1}{16}$ of an effective symbol length,

wherein the TDD frame includes a downlink interval and an uplink interval that is located subsequent to the downlink interval,

wherein a Transmit Transition Gap (TTG) interval is located between the downlink interval and the uplink interval,

wherein a Receive Transition Gap (RTG) interval is located next to a last uplink subframe of the uplink interval, wherein a total length of the TTG interval and the RTG interval is 240 μs,

wherein the downlink interval includes four downlink subframes comprising three type-1 downlink subframes that include six Orthogonal Frequency Division Multiple Access (OFDMA) symbols and a type-3 downlink subframe that includes five OFDMA symbols,

wherein a first downlink subframe of the three type-1 downlink subframes is configured to include a superframe header,

wherein the type-3 subframe is located subsequent to the three type-1 downlink subframes,

wherein the uplink interval includes two uplink subframes comprising only a type-1 uplink subframe that includes six OFDMA symbols,

wherein the type-1 uplink subframe has a length of 0.816 ms and the type-3 downlink subframe has a length of 0.680 ms,

wherein the type-1 uplink subframe has a same size as a subframe included in a Frequency Division Duplex (FDD) frame having a channel bandwidth of 7 MHz, the FDD frame configured to have a Cyclic Prefix length corresponding to 1/16 of an effective symbol length.

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